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APR 80 J BAILEY, R G HUGHES, W E JONES

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APPLICATION OF BACKWARD CHAINING TO AIR-TO-SURFACE WEAPONS DELIVERY TRAINING

By

Jon Bailey
Ronald G. Hughes
William E. Jones, Lt, USAF

FLYING TRAINING DIVISION
Williams Air Force Base, Arizona 85224

April 1980
Interim Report for Period May 1978 – September 1978

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AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

This interim report was submitted by the Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under Project 1123, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235. Dr. Jon Bailey was the Principal Investigator for the Laboratory.

This technical report has been reviewed and is approved for publication.

DIRK C. PRATHER, Lieutenant Colonel, USAF
Technical Advisor, Flying Training Division

RONALD W. TERRY, Colonel, USAF
Commander

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Experienced pilots acquired a 30-degree dive bombing task in the Advanced Simulator for Pilot Training (ASPT). Half the subjects acquired the task under a "whole task" approach: half under a "backward chaining" approach. Criterion performance was defined in terms of circular bomb error. The results indicated that subjects in the backward chaining group performed significantly better than subjects in the whole task group when training time for the two groups was equated. The results demonstrate that backward chaining may be used to significantly enhance the effectiveness of simulator-based instruction on a sequential task such as manual dive bombing. The results provide an important demonstration of the appropriateness of basic learn-

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ing theory principles and techniques for generating effective instructional approaches utilizing the unique capabilities of the flight simulator.

PREFACE

This effort was conducted by the Flying Training Division of the Air Force Resources Laboratory (AFHRL), Williams AFB. The project was completed under Work Unit 1123-02-34, entitled Advanced Instructional Features and Methods in ASPT. The work unit supports Project 1123, Flying Training Development, Task 02, Instructional Innovations in Flying Training. This effort further supports AFHRL Planning Objective G03, Specific Goal 2, Training Methods and Media.

Dr. Bailey's participation in the study was completed during his assignment to the Laboratory under the 1978 USAF-ASEE Summer Faculty Research Program, sponsored by the Air Force Office of Scientific Research.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Preceding Page Blank -

APPLICATION TO BACKWARD CHAINING TO AIR-TO-SURFACE WEAPONS DELIVERY TRAINING

I. INTRODUCTION

Most complex behaviors may be best described as sequences or chains of behavior (Kazdin, 1975). The implications of analyzing a task to be performed as a series of behaviors is that those responses furthest removed from reinforcement will not be strengthened maximally and may slow the acquisition of the behavior. The concept is not new (Skinner, 1938), and suggestions for teaching chains of behavior are readily apparent in behavioral texts (Bailey & Hughes, 1980; Kazdin, 1975; Martin & Pear, 1978). Basically, in training the task by backward chaining, the task is arranged so that the last member of the chain occurs first; it is followed by reinforcement, and then the next-to-last response is added and so on. While the procedure seems clear enough and the implications for solving applied problems are not difficult to envisage, there has been surprisingly little applied work on chaining. The work that has been done to date (Hollander & Horner, 1975; Martin, England, & England, 1971) has been rather informally controlled so that actually comparing chaining with a whole task method is not yet possible.

It is important to note that perhaps the only carefully controlled study with humans (Weiss, 1978) showed that forward chaining of a button pushing task was actually superior to backward chaining. In this study, however, the task was an artificial chain of behavior, and the forward chaining might have also been conceptualized as a shaping procedure. Thus, backward chaining versus whole task learning with an actual applied behavior has yet to be demonstrated in the research literature.

In flying training, many of the tasks to be acquired may be conceptualized as chains of behavior (e.g., circling the runway and landing—referred to as the overhead traffic pattern). More importantly, if failure to perform the overhead pattern is cited as a significant factor in undergraduate pilots being "washed out" (Eddowes & King, 1975), being able to teach the task more effectively may result in a direct savings to the Air Force. Advanced pilots are confronted with a topographically similar task when they learn air-to-ground combat and must learn to perform the 30-degree dive bomb task. The similarity to the overhead pattern and ready access to advanced pilots as subjects, as well as an existing simulation capability for the dive bombing task, all made carrying out a study on chaining with this task feasible. The chief purpose of the study was to evaluate the feasibility of comparing the whole task method with the backward chaining method in teaching the 30-degree dive bombing task.

II. METHOD

Subjects. Twenty Air Force Instructor Pilots (IPs) assigned to Williams AFB served as subjects. All were assigned as instructors in the Undergraduate Pilot Training (UPT) program and were experienced with the handling characteristics of the T-37 aircraft being simulated. None had prior experience with the 30-degree dive bomb task used in the present study.

Apparatus. The Advanced Simulator for Pilot Training (ASPT) located at the Flying Training Division of the Air Force Human Resources Laboratory was used for training of the air-to-surface weapons delivery task. Technical references for this device are found in Gum, Albery, and Basinger (1975) and in Rust (1975). For the study, the G-seat was inflated but not otherwise in operation. Neither was the motion platform used in the present study. The computer-generated visual scene consisted of a representation of the Gila Bend Gunnery Range in Arizona (see also Gray & Fuller, 1977; Hughes, Paulsen, Brooks, & Jones, 1978). The visual scene was presented via the seven 36-inch monochromatic cathode ray tubes placed around the ASPT cockpit, giving the pilot + 110 degrees to -40 degrees vertical cueing and ±150 degrees of horizontal cueing. The standard T-37 cockpit configuration was modified through the addition of a depressible bombing sight. The aerodynamic mathematical models driving the simulator were those simulating the T-37 aircraft.

Procedure. Upon arrival at the laboratory, the subjects read a programmed text on the 30-degree dive bomb task (see Appendix A). Following an informal test to insure comprehension of the material, each subject was briefed on the task by the senior IP assigned to the study. The subject and the IP then entered the simulator and together viewed a recorded demonstration of the 30-degree dive bomb task. The IP then got out of the simulator, and the device was initialized on the downwind leg of the pattern (see Figure 1).

All subjects, regardless of subsequent group assignment, flew five repetitions of the task for the purpose of determining initial entry level of performance. On these trials, no feedback was given other than circular error and release parameters. Beyond this point, the manner in which subjects continued to practice the task was determined by their assignment to one of the two different instructional approaches . . . either "whole task" or "backward chaining."

For subjects in the backward chaining condition, the dive bomb task was divided into four segments: final, roll-in, base, and downwind (see Figure 2). Subjects in the backward chaining condition were initialized first at the beginning of the final leg segment, taken off freeze, and allowed to fly the task from that point to completion. After reaching a criterion of two consecutive bombs with a circular error of 140 feet or less, the subject was moved back to the next segment of the chain (in this case, the roll-in segment). In a like manner, the 'base leg' and 'downwind leg' links of the chain were added. Once criteria performance was achieved from the downwind position the subjects were given a block of five trials without feedback. Mean performance for these five trials was taken as the subject's "terminal" performance.

Subjects in the "whole task" condition following the initial five no-feedback trials were initialized at the downwind starting point and from that point, flew the task to completion. Training was continued for approximately 30 trials.

III. RESULTS

The primary dependent measure was the circular error score (i.e., distance of simulated bomb impact from the target). Comparisons of main concern dealt with (a) entry level performances prior to training, (b) differences between groups as a function of instructional approach, given equal training time, and (c) differences in the percentage of subjects reaching criterion.

With respect to the first question, a comparison of the mean baseline performances of individuals across the two instructional groups revealed no statistically significant differences. The two groups can thus be considered to have been matched on the basis of initial entry level skill.

In dealing with the second question, some explanation is necessary to describe how the data were treated in order to equate training time for the two experimental groups. First, the mean time required for an individual to achieve criterion under the backward chaining condition was determined. This unit of time was then taken as the period of training time over which the two groups would be compared. Then, based on the average time required for a "trial" under the whole task condition, it was determined how many practice trials could have been conducted in this period of time. Numerically, the results indicated that in the mean time required for an individual in the backward chaining condition to reach criterion, an individual could have practiced approximately 14 trials under the whole task condition. Terminal performances for subjects in the backward chaining condition were taken as the mean of the five-trial "post-test" baseline period. Under post-test conditions, the subjects flew without guidance from the instructor pilot. The only feedback provided was information on circular error and release parameters. Terminal performances for subjects in the whole task condition were taken as the mean of trials 15 to 19 (i.e., the five trials immediately following the completion of a period of training equal to that of subjects in the backward chaining condition).

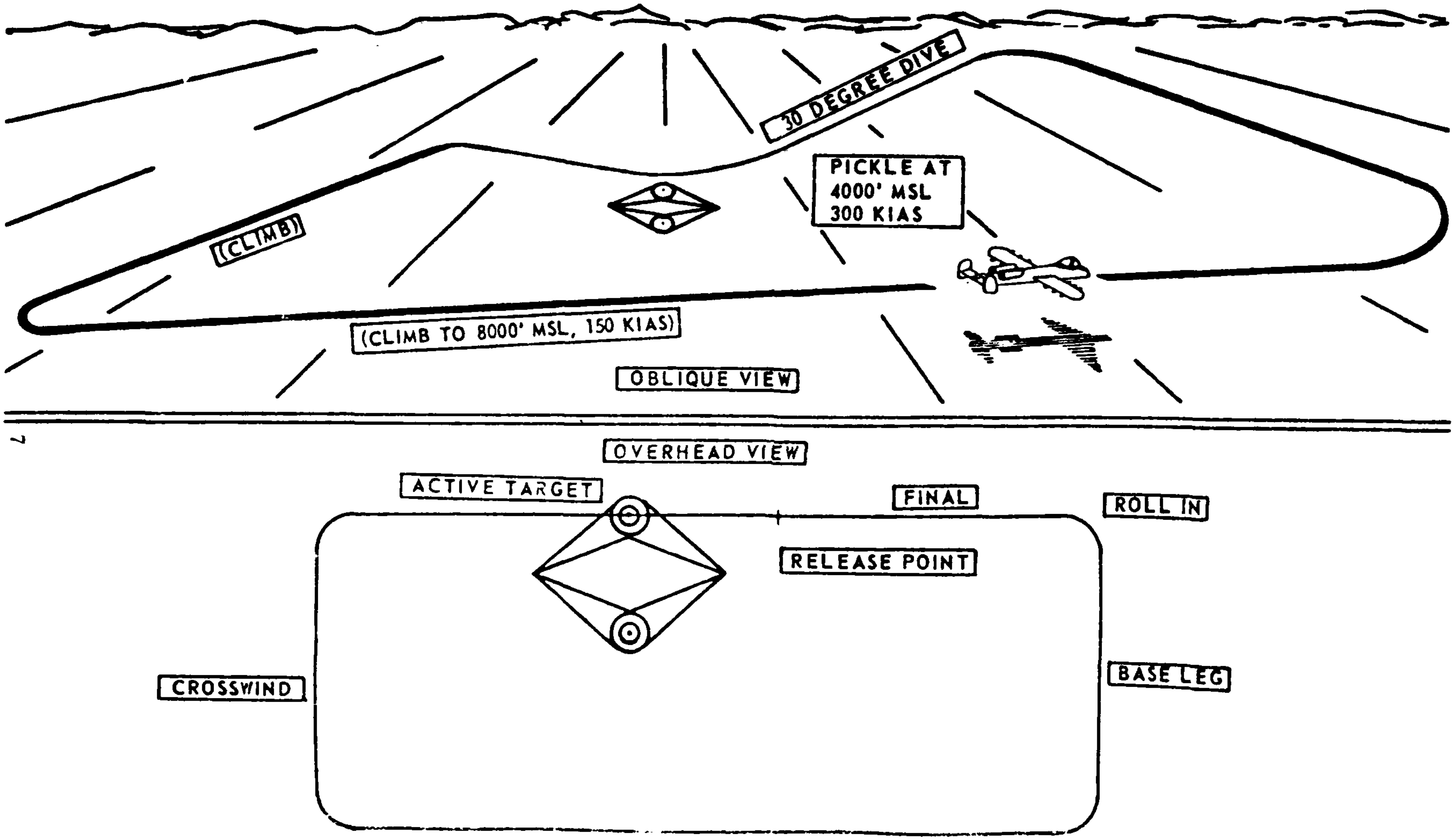

Figure 1. **30^{o} dive bomb task.**

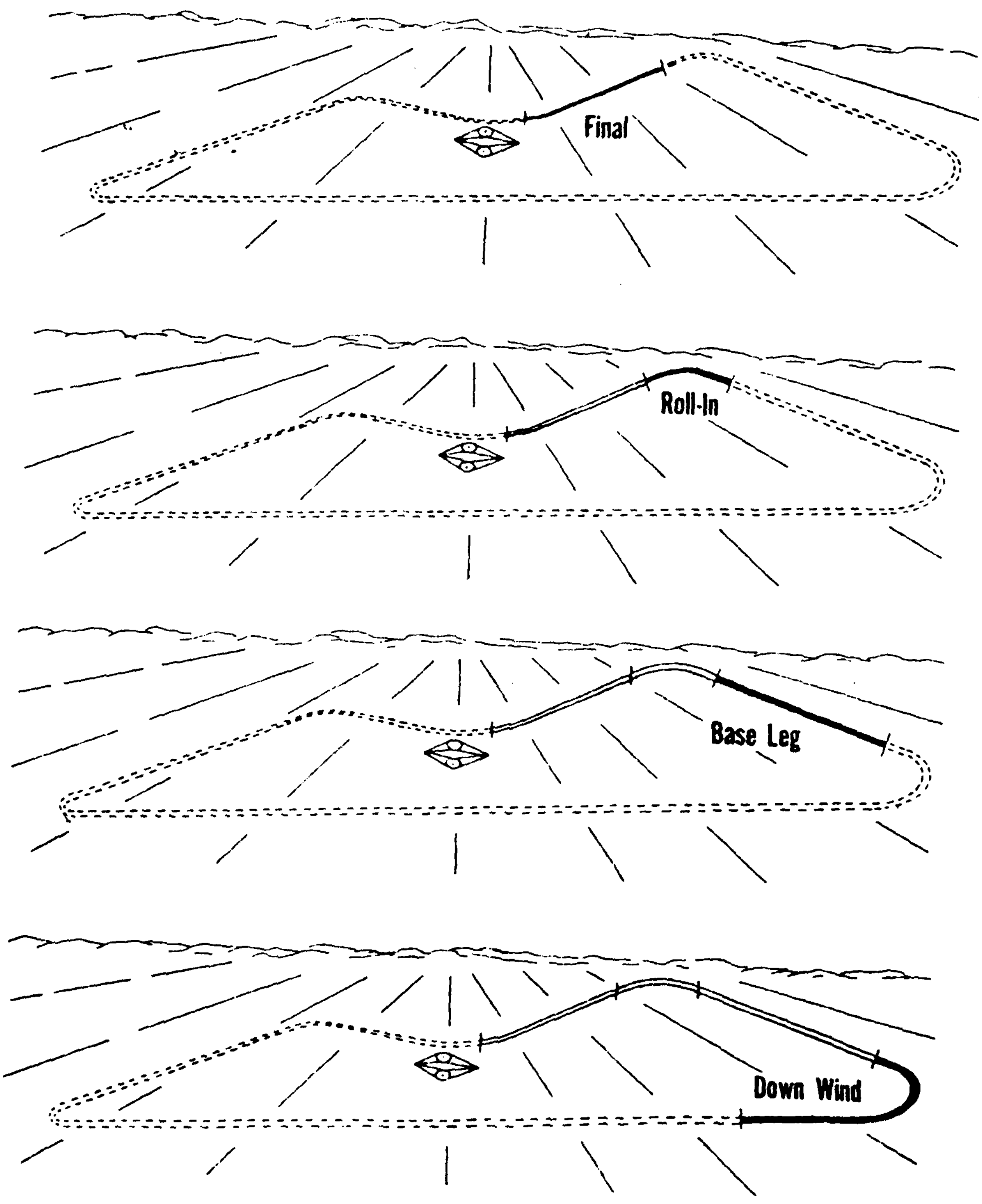

Figure 2. **Backward chaining approach.**

The mean circular error for the two experimental groups is presented in Figure 3. The results of these performance comparisons were as follows. The mean circular error for subjects in the backward chaining condition was 134.38 feet. The mean circular error for subjects in the whole task condition was 182.34. The approximate 26 percent difference in accuracy is statistically significant ($X^2 = 5.0$, df $= 1$, $p < .05$). The results indicate that, given equal training time, accuracy of bomb delivery for subjects trained under the backward chaining condition was significantly better than the accuracy of subjects trained under the whole task condition.

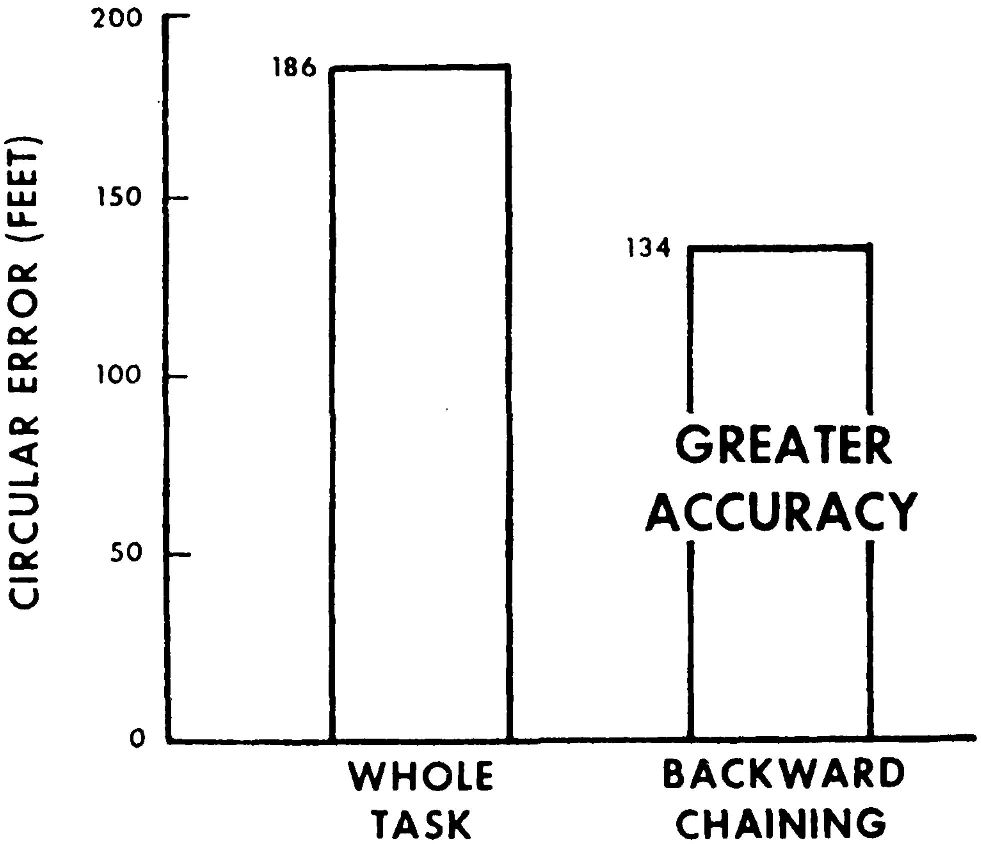

Figure 3. **Comparison of performances given equal training time.**

Using the same period of time as a reference point, it was determined that in the time required for 7 of 10 pilots in the backward chaining condition to reach criterion, only 3 of 10 pilots in the whole task condition had done so (see Figure 4). Thus, not only was the accuracy of subjects in the backward chaining condition better when training time for the two groups was equated, but the rate at which students reached criterion was significantly faster under the backward chaining condition.

IV. DISCUSSION

The results of the present study indicate a clear, systematic reduction in circular error with the use of a backward chaining method for introducing the 30-degree dive bomb task. It should be made clear that the effectiveness of backward chaining in the present study does not address the potential effectiveness of forward chaining as an alternative to the whole task approach.

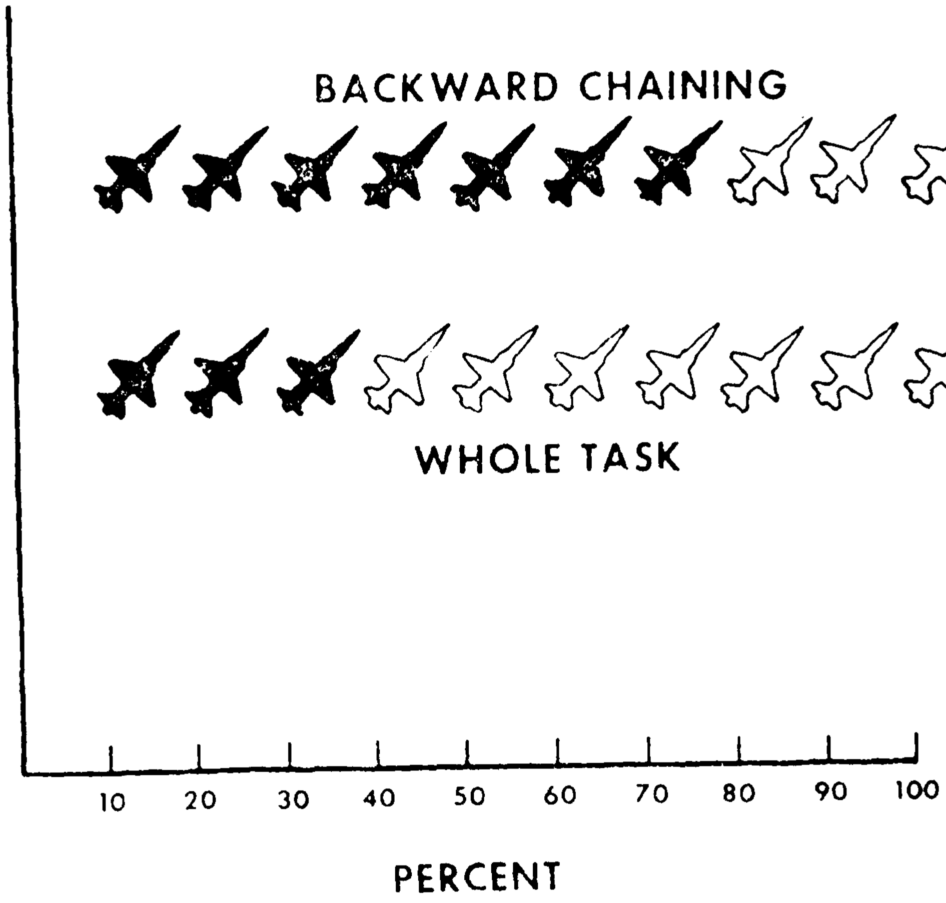

Figure 4. Percent reaching criterion.

Both chaining methods have several advantages over traditional whole task methods for the training of such tasks. With the task broken into segments, less information must be processed on any given trial, presumably allowing learning to occur more efficiently. In addition, by starting with the last element in a backward sequence, the subject can more often come into contact with the reinforcer for successful execution of the task. Under forward chaining approaches, moving into the next link of the chain is usually made contingent upon successful performance in the preceding link. Under forward chaining, poor performance results in the student's being terminated prior to completing the task. In the case of weapons delivery training, given the same criterion for terminal performance, the student under the backward chaining method would have the opportunity to drop more bombs per unit of training time than would a student under the whole task method or forward chaining method. Given that dropping bombs is the essence of the task, backward chaining allows more practice time than does either forward chaining or the whole task method. In short, for the 30-degree dive bomb task, backward chaining provides for the most efficient use of available training time.

The application of behavior principles to problems of flying training would appear to represent an approach worthy of further research. Tasks, such as weapons delivery, allow for easy quantification of the dependent variable, and parallel other significant maneuvers that must be mastered by pilots (e.g., overhead traffic pattern, carrier landings, and aerial refueling). Furthermore, the ability to vary other dimensions of the task (e.g., speed of the aircraft, size of the target, and difficulty of control dynamics) should allow precise comparisons of various methods of teaching such tasks. It is hoped that this study will pave the way toward a heightened research effort in the application of behavior principles to problems of flying training.

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APPENDIX A: PROGRAMMED TEXT

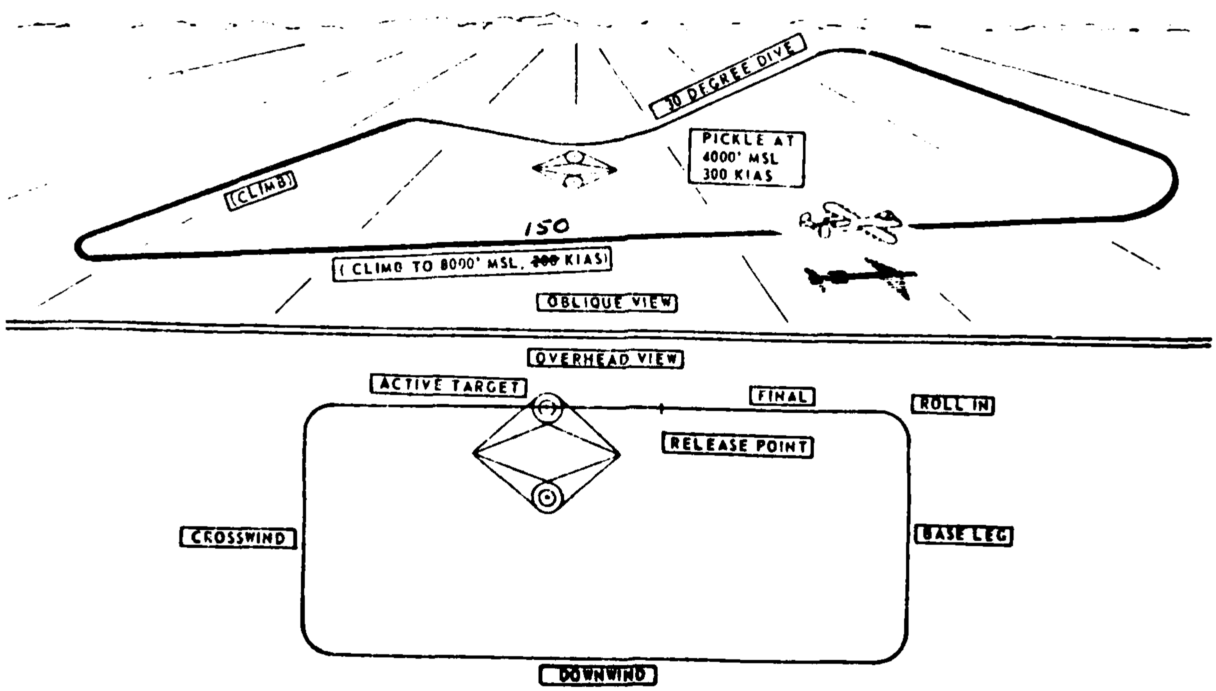
Instructions

Where directed, use a 5 x 8 card to cover answers while responding to questions in this program. This is a programmed text to acquaint you with some of the fundamentals of 30-degree dive bombing. Explanations, diagrams, and questions are provided. Study the diagrams and text carefully before answering the questions. Supply a one-word answer for each blank line shown in the questions. Two-word answers, if called for, are shown with two lines (   ). After you have written in your answers, slide the card down the page to check the correct answer. If you answer incorrectly, re-read the material to ensure you understand the information.

30-DEGREE DIVE BOMB PROCEDURES

Diagram 1 on the next page shows the basic pattern used for tactical bombing practice. Study the diagram until you are familiar with the layout, legs, and flight parameters. Notice that the pattern consists of crosswind, downwind, base, and final legs.

DIAGRAM 1
BOMBING PATTERN



As can be seen, the bombing pattern is similar to a landing pattern. The bomb run on final compares to final approach for landing; the angle of dive is similar except in the number of degrees to the glide slope on landing final. Notice also, that the crosswind and downwind legs are used to establish 8000 feet MSL an sea level at 150 KIAS ots indicated air speed. The parameters are held during the base leg. For a 30-degree dive, the dive angle and alignment on target are executed so as to achieve a release point at 4000 feet MSL at 300 KIAS. Either the right or left target is designated as the active target by the Range Control Officer prior to execution of the pattern. The bombing pattern base leg is almost the same as the GCA ound controlled approach pattern base leg. The same comparison can be made for the crosswind and downwind legs on both types of patterns.

(Use a 5 x 8 card to cover answers while responding to questions on this page)

The bombing pattern is similar to a GCA pattern in that it has _____, _____, _____, and _____ legs.

//

ANSWERS: Crosswind, Downwind, Base, Final.

During the crosswind and downwind legs of the pattern altitude of _____ MSL and airspeed of _____ KIAS should be established.

//

ANSWERS: *8000 feet, 150.*

Bomb release parameters for a 30-degree dive bomb are _____ MSL and _____ KIAS.

//

ANSWERS: 4000, 300.

The determination of which target (right or left) will be used as the active target is made by the

//

ANSWER: Range Control Officer.

Bombing Procedures

The basic concepts for air-to-ground deliveries were developed by pilots and are expressed in the terminology of everyday flying.

The best way to drop a bomb with reasonable accuracy is to fly your aircraft smoothly over the target area and release the bomb at a point in space that will cause the bomb to impact on the target center. This concept involves two key elements: smoothness and precise release point.

Smoothness. The development of accuracy and consistency in bomb deliveries demands that the pilot use smooth aircraft control technique. This is especially important during target acquisition, tracking, pickling, and followthrough. The importance of smoothness for bomb release is analagous to smoothness in firing a rifle or shotgun, hitting a golf or tennis ball, or performing similar kinds of sports skills. Any tendency to interrupt the smoothness of the action by pulling or jerking will adversely influence performance. Not only must the pilot learn to squeeze off the pickle, but must also maintain target tracking for a brief time following pickle to insure a smooth follow through.

(Use a 5 x 8 card to cover answers while responding to questions on this page)

Smoothness of aircraft control influences both ______ and ______ in bomb deliveries.

//

ANSWERS: Accuracy, consistency

Release Point. **At the point of release from the aircraft, the direction, altitude, and energy (or momentum) of the bomb will determine its impact point. Therefore, the pilot must pickle at a precise airspeed, altitude, dive angle and G-load over an exact ground point. The pilot can develop bombing proficiency by keeping the ideal pickle point in mind as a guide. The attainment of these parameters on a consistent basis, combined with smooth aircraft control and pickle technique will ensure high scores at the range.**

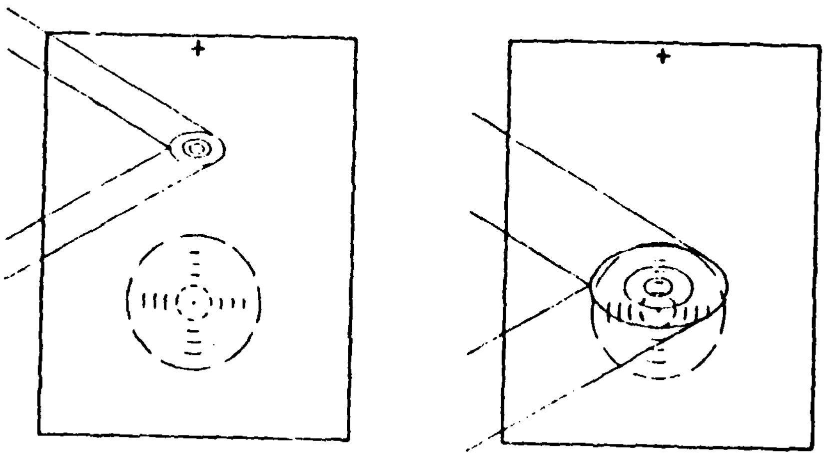
(Use a 5 x 8 card to cover answers while responding to questions on this page)

The release point should be at a precise _______, _____________, _______________________ ___________, and _______over an exact ______ point.

//

ANSWERS: airspeed, altitude, dive angle, g-load, ground

DIAGRAM 3. BOMBSIGHT



ILLUSTRATIONS OF BOMBSIGHT AND TARGET ALIGNMENT. CROSS AT TOP OF SIGHT IS A/C NOSE OF AIRCRAFT. CENTER CIRCLE AND DOT IS PIPPER. SCALED MARKINGS ARE FOR PARAMETER ALIGNMENTS AND WILL BE EXPLAINED IN DETAIL LATER. NOTE THE RELATIVE POSITION OF A/C NOSE AND PIPPER TO TARGET. AT LEFT, APPROACHING TARGET. AT RIGHT, NEAR TARGET

Roll-In Procedures. Correct roll-in is achieved using whatever lead point and bank angle necessary to align the aircraft with the target run-in line (correct final ground path) and to position the longitudinal axis of the aircraft (ATC nose) slightly beyond the target (refer to Diagram No. 2).

This will result in a specific dive angle. Hold this angle while crosschecking increasing airspeed and decreasing altitude to achieve 300 KIAS and 4000 feet MSL simultaneously. This is the release point. Note that the dive angle achieved is a function of the proximity of the base leg to the target. The correct angle for this exercise is 30 degrees. Thus, if the angle achieved is less than 30 degrees (too flat) the base leg has been set too far away from the target. On the next pattern, the base leg should be "moved in" (closer to target). Conversely, a dive angle of more than 30 degrees (too steep) indicates that the base leg has been set too near the target and should be "moved out." A glance at the attitude indicator during the dive will tell you the angle achieved and whether adjustment of the base leg position will be necessary on the next pattern.

Roll-in should be done so that the ATC nose of the aircraft is positioned slightly______ the target.

//

ANSWER: Beyond

During the dive you should crosscheck increasing _____Fand decreasing _____to achieve a release point of _____ KIAS and _____feet MSL.

//

ANSWERS: Airspeed, Altitude, 300, 4000.

The dive angle achieved during a given dive results from the distance between the target and the ________.

//

ANSWER: Base Leg

You can check how close you are to the proper angle during a dive by glancing at the ____________.

//

ANSWER: Attitude Indicator

An achieved dive angle of 15 degrees on an attempted 30 degree dive pattern indicates that the distance between the target and the next base leg should be ______________________________.

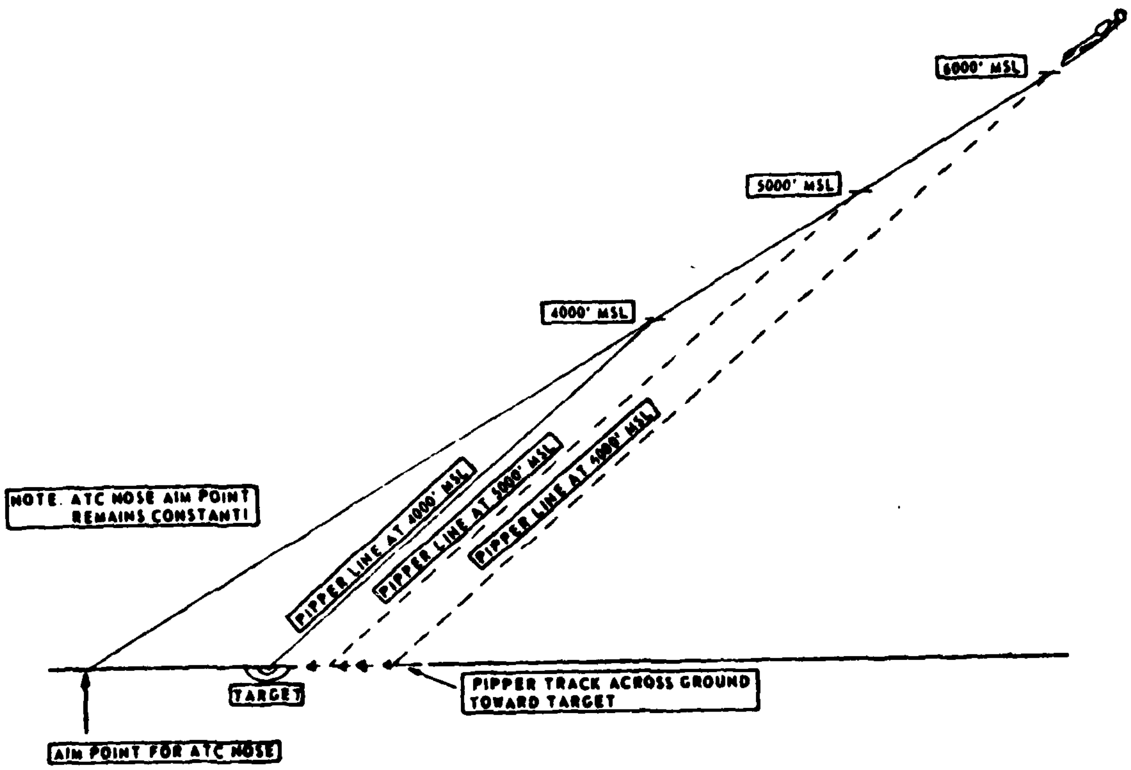
//

ANSWER: Decreased or Shortened.

Using the Bomb Sight. This is the most misused piece of equipment in the cockpit. There is a natural tendency to start using the sight, that is, trying to line it up on target, too early. This is sometimes called "flying the bomb sight." But using the bombsight before you have correctly positioned the aircraft is like trying to adjust the fine tuning on a TV set before selecting the channel. So, you should strive to fly the plane first and track the sight second.

PIPPER TRACK

DIAGRAM 3



As you fly toward the target on final, the ATC nose should be slightly above or beyond the target. Since the pipper is fixed at a point below the ATC nose, it should track toward the center of the target. Look at Diagram 3. Notice that the ATC nose of the aircraft remains at a constant point relative to the target throughout the dive. But look at the relationship of the pipper to the target. At the beginning, on top of the dive it will appear well below the target. As the aircraft approaches the target, the pipper will track toward, or close on, the target, because the angle or relationship between the ATC nose and the pipper is constant. The pipper will appear to swing around the target if you rock the wings. As mentioned, you may be tempted to "chase" the pipper to achieve target alignment. But this is like chasing the VVI; the more you chase it, the worse it gets. If the pipper is not moving where you want it to, force your attention back to flying the aircraft, that is, flying it to the target as if there were no bombsight in the cockpit. Re-aim the *aircraft*, then watch the pipper's new track. By doing this, with a little practice, you will learn to make small, smooth adjustments of the pipper's track. The trick is to keep your primary interest in controlling the aircraft while being aware of the pipper track. Of course, you are looking for the aircraft to pass through 4000 feet MSL and 300 KIAS with the 30 degree dive angle at the same instant that the pipper "sneaks" through the bullseye.

With the ATC nose of the aircraft positioned slightly______ the target, the pipper should be approximating the track toward the ______.

//

ANSWERS: Above or Beyond, Target

You should concentrate your effort first on controlling the ______ and secondly on tracking the ______.

//

ANSWERS: Aircraft, Pipper

Your objective is to achieve a bomb release point at ______ feet MSL, ______KIAS, with the 30-degree dive angle and with the ______ on the ______.

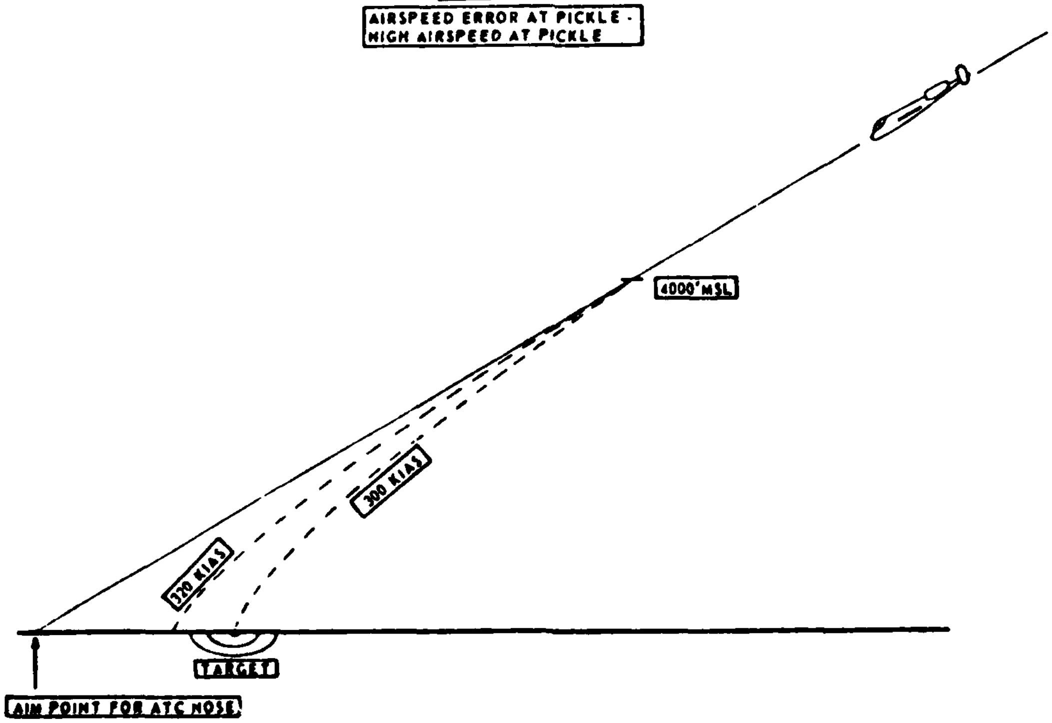
//

ANSWERS: 4000, 300, Pipper, Bullseye or Target

Common Errors. The most common errors in the 30-degree dive bomb result from deviations from the critical release parameters: altitude, airspeed, dive angle, and G-load. Understanding how deviations from these parameters effect impact point is important as the first step in effective practice. Study and *be able to apply reasoning for each of the concepts discussed on the following pages.*

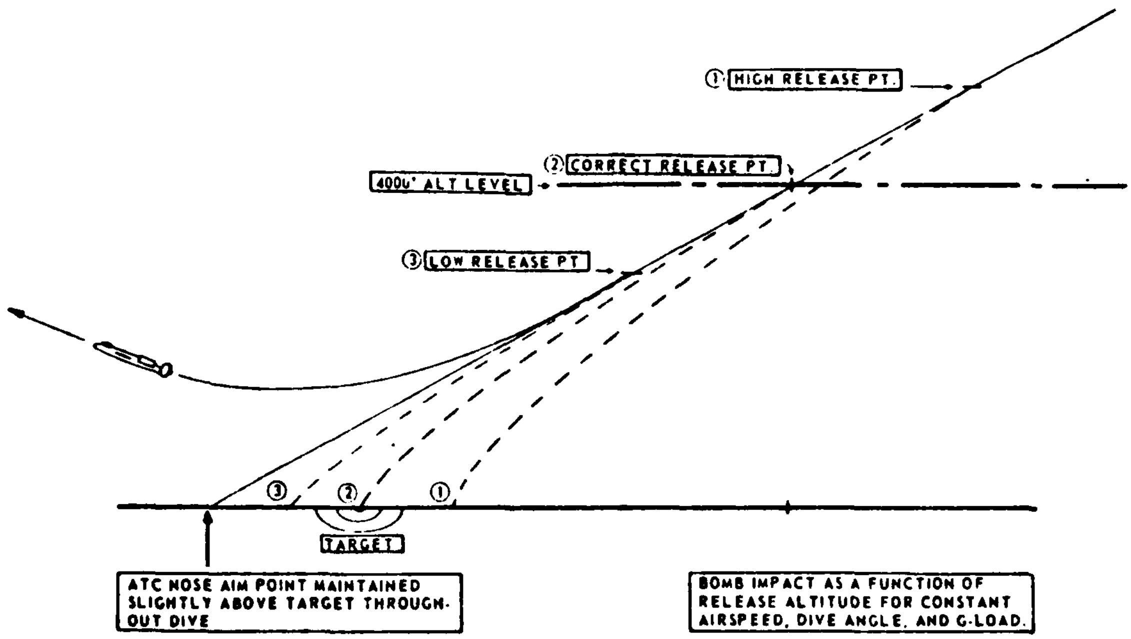
DIAGRAM 4

AIRSPEED ERROR AT PICKLE - HIGH AIRSPEED AT PICKLE



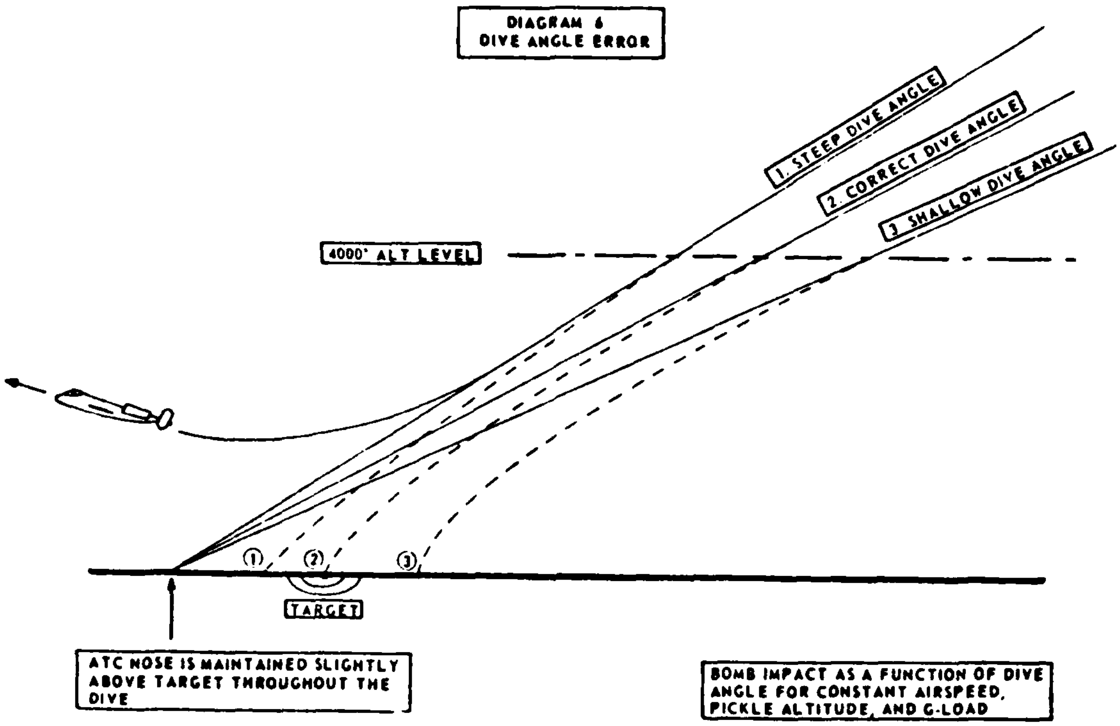
Airspeed Error. 300 KIAS at pickle is critical since at this precise speed (given that other parameters are correct) the direction and energy of the falling bomb will result in proper impact on target. So speeds over 300 KIAS (fast) will result in "long" bombs, or impact beyond the target. Conversely, speeds less than 300 KIAS (slow) will result in "short" impacts.

DIAGRAM 5
ALTITUDE ERROR



Altitude Error. Pickle at 4000 feet MSL will result in proper impact, given that other parameters are correct. Pickling above this altitude (along the glide path) will produce a short bomb. Look at diagram 5. As you fly down the glide path, suppose you release high, as shown in release point 1. You are, in fact, releasing the bomb too early resulting in impact short of the target. On the other hand, if you pickle below 4000 feet, as shown in release point 3, you will be delaying release resulting in the bomb going beyond the target (impact point 3). Point 2 in the diagram shows the result of pickle at the correct altitude.

Variance from the correct angle of dive will also influence the bomb impact point. As with the other critical parameters, the correct dive angle, given other parameters are correct at pickle, will result in a bullseye bomb. However, if you are off on dive angle, you can expect to be off at impact. Look at Diagram 6. As you fly down the glidepath with the ATC nose set slightly above the target, if your dive angle is too steep (Example 1), pickling at the 4000 foot level will result in a long bomb. If your angle is too shallow (example 3), a 4000 foot pickle will give you a short bomb.



Improper G-Loads. Variance from proper g-load on the aircraft will also influence bomb impact point. It is important to maintain a constant g-load throughout the dive. This is one reason why we have stressed smoothness as a technique in bombing. At pickle, a low g condition will result in long bombs. Low g's, in effect, are like dropping light bombs in that the low G's cause the bomb to drop long. Conversely, high G's have the same effect as heavier than normal bombs, causing impact short of the target. The important thing then is maintaining normal g-loading at the pickle point.

Bank Error. As previously mentioned, rocking the wing during the dive will cause the pipper to swing like a pendulum under or across the target. The wings must be level at the release point. With other parameters correct, left bank will cause bomb impact to the left of the target; right bank will cause impact to the right.

(Use a 5 x 8 card to cover answers while responding to questions on this page.) For each of the following questions, determine if the bomb will fall long or short of the target. Given that dive angle, altitude, and G-loads are correct, pickle at an airspeed of 320 KIAS will result in a _______bomb drop.

//

ANSWER: Long

Given that dive angle, airspeed, and G-loads are correct, pickle at 4300 feet MSL will result in a ____ bomb drop.

//

ANSWER: Short

Given that airspeed, altitude, and g-loads are correct, pickle at a dive angle steeper than 30 degrees will result in a_____bomb drop.

//

ANSWER: Long

Given that airspeed, altitude, and dive angle are correct, high g-loads at pickle will result in a_____bomb drop.

//

ANSWER: Short

Given that all other parameters are correct, a slight amount of right bank at pickle will result in bomb impact at the _____ of the target.

//

ANSWER: Right

Bombing Parameter Interactions. "Compensating error" is a common expression. The idea is that a particular kind of error can be corrected by a corresponding error in another parameter. For example, pickle at too shallow a dive angle will cause the bomb to drop short. But this error can be offset by boosting airspeed. If the two errors are properly matched you will get a good bomb. You can also have the interaction of more than two parameter errors such as errors in airspeed, altitude, and dive angle combining in such a way that the variances from correct values at pickle cancel out one another and you have a good bomb. As is obvious, learning to bomb via the compensating error method is complex and inefficient. It leads to bad habits and inconsistent scores. The best and simplest way to learn is to get everything right at the pickle.

REMEMBER!!! THE SINGLE MOST IMPORTANT FACTOR IN DROPPING CONSISTENT, ACCURATE BOMBS IS: FLY THE AIRPLANE AS THOUGH YOU DON'T HAVE A PIPPER. USE THE PIPPER ONLY AFTER YOU ARE ESTABLISHED ON FINAL WITH EVERYTHING LOOKING GOOD!

When you are satisfied that you fully understand this material, ask for the test.

BOMBING PRIMER TEST

Select the answer which best completes each statement or question.

1. Which of the following parameters are used for the downwind leg of the 30-degree bombing pattern?

   a. 200 KIAS, 4000 feet MSL.
   b. 150 KIAS, climbing to 8000 feet MSL.
   c. 300 KIAS, 8000 feet MSL.
   d. 300 KIAS, 4000 feet MSL, level flight.

2. Which of the following parameters are used during the *base leg*?

   a. 200 KIAS, 4000 feet MSL.
   b. 200-250 KIAS, 400 feet MSL, level flight.
   c. 150-200 KIAS, 8000 feet MSL.
   d. 150 KIAS, 8000 feet MSL.

3. Correct parameters for *bomb release* for the 30-degree dive bomb are:

   a. Accelerating to 300 KIAS, 8000 feet MSL.
   b. 300 KIAS, 4000 feet MSL.
   c. 300 KIAS, 8000 feet MSL, wings level
   d. Accelerating to 300 KIAS, 30-degree dive, wings level.

4. Attainment of accurate bomb releases depend upon smooth aircraft control combined with:

   a. the right pickle parameters.
   b. achieving correct base-leg position.
   c. proper downwind position.
   d. correct altitude.

5. The best way to determine how close you are to correct dive angle is:

   a. to check the bomb's impact.
   b. to release the bomb early, if required.
   c. to check the attitude indicator.
   d. to adjust your roll-in.

6. If your dive angle is 38 degrees, you should:

   a. reduce airspeed.
   b. decrease dive angle.
   c. adjust base leg on next pattern.
   d. both "a" and "b" above.

7. A common mistake in bombing practice is:

   a. aligning the aircraft before using the bomb sight.
   b. aligning the ATC nose before aligning the pipper.
   c. aligning the base leg before aligning the final.
   d. aligning the pipper before aligning the ATC nose.

8. During the dive, assuming that the ATC nose is correctly positioned, the pipper should:

   a. track closing on the target.
   b. be positioned slightly above the target.
   c. track centered on the target.
   d. remain well below the target.

9. If, during the dive, the pipper does not move where you want it to, you should:

   a. decrease or increase angle of attack.
   b. re-align the ATC nose, then recheck the pipper.
   c. adjust airspeed and altitude.
   d. re-align the pipper, then check dive angle.

10. The *best* description of the relationship between the ATC nose and the pipper is:

   a. a decreasing angle as target is approached.
   b. that the pipper stays below the target, the ATC nose stays above.
   c. a fixed angle as target is approached.
   d. an increasing angle as target is approached.

11. Which item *best* describes the position of the ATC nose and pipper at the release point?

   a. ATC nose on target, pipper on target.
   b. ATC nose above target, pipper above target.
   c. ATC nose above target, pipper below target.
   d. ATC nose above target, pipper on target.

12. Which of the following parameter descriptions will result in a long bomb?

   a. Dive angle, A/S, g-load all correct, pickle at 3800 feet.
   b. A/S, g-load, altitude all correct, pickle at 25 degrees dive angle.
   c. G-load, dive angle all correct, pickle at 280 KIAS.
   d. Altitude, A/S, dive angle all correct, pickle with high G's.

13. Which of the following parameter descriptions will produce a short bomb?

   a. All other parameters correct, pickle at 35 degrees angle.
   b. All other parameters correct, pickle at 4200 feet.
   c. All other parameters correct, pickle at low G's.
   d. All other parameters correct, pickle at 310 KIAS.

14. The movement of the pipper during bank changes:

   a. is the same as the ATC nose.
   b. can be used to determine lead points.
   c. is the same direction as the bank angle.
   d. is similar to a pendulum.

15. Select the most correct statement:

   a. a.gYou should roll out of the turn-to-final with the pipper on target.
   b. You should roll out of the turn-to-final with the ATC nose on target.
   c. You should roll out on final with the pipper beyond the target and the ATC nose short of the target.
   d. You should roll out on final with the ATC nose beyond the target and the pipper short of the target.

16. The angle of bank used for rolling in on final is:

    a. less than 30 degrees.
    b. more than 30 degrees, less than 60 degrees.
    c. more than 60 degrees, but less than 90 degrees.
    d. nobody cares.

17. Dropping accurate bombs will:

    a. improve general airmanship.
    b. improve morale.
    c. make you feel good.
    d. all of the above.

ED

80